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$\alpha_s(M_Z^2)$ in NNLO Analyses of Deep-Inelastic World Data

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The present world data of deep-inelastic scattering (DIS) reached a precision which allows the measurement of $\alpha_s(M_Z^2)$ from their scaling violations with an error of $\delta\alpha_s(M_Z^2) \simeq 1\%$. This requires at least NNLO analyses, since NLO fits exhibit scale uncertainties of $\Delta_{r,f}\alpha_s(M_Z^2) \sim 0.0050$. The NNLO values for α_s obtained are summarized in the following Table.

	$\alpha_s(M_Z^2)$	
BBG	$0.1134\ ^{+0.0019}_{-0.0021}$	valence analysis, NNLO [1]
GRS	0.112	valence analysis, NNLO [2]
ABKM	0.1135 ± 0.0014	HQ: FFNS $N_f = 3$ [3]
ABKM	0.1129 ± 0.0014	HQ: BSMN-approach [3]
JR	0.1124 ± 0.0020	dynamical approach [4]
JR	0.1158 ± 0.0035	standard fit [4]
MSTW	0.1171 ± 0.0014	[5]
ABM	0.1147 ± 0.0012	FFNS, incl. combined H1/ZEUS data [6]
Gehrmann et al.	$0.1153 \pm 0.0017 \pm 0.0023$	e^+e^- thrust [7]
Abbate et al.	$0.1135 \pm 0.0011 \pm 0.0006$	e^+e^- thrust [8]
BBG	$0.1141\ ^{+0.0020}_{-0.0022}$	valence analysis, N^{3}LO [1]
world average	0.1184 ± 0.0007	[9]

NNLO non-singlet data analyses have been performed in [1, 2]. The analysis of Ref. [1] is based on an experimental combination of flavor non-singlet data referring to $F_2^{p,d}(x, Q^2)$ for $x < 0.35$ and using the respective valence approximations for $x > 0.35$. The $\overline{d} - \overline{u}$ distributions and the $O(\alpha_s^2)$ heavy flavor corrections were accounted for. At low Q^2 and at large x also at low W^2 higher twist corrections have to be taken into account [10]. The corresponding region was cut out in [1] performing the fits for the leading twist terms only. The analysis could be extended to N^{3}LO effectively due to the dominance of the Wilson coefficient in this order [11] if compared to the anomalous dimension, cf. [1,12]. This analysis led to an increase of $\alpha_s(M_Z^2)$ by $+0.0007$ if compared to the NNLO value.

A combined singlet and non-singlet NNLO analysis based on the DIS world data, including the Drell-Yan and di-muon data, needed for a correct description of the sea-quark densities, was performed in [3]. In the fixed flavor number scheme (FFNS) the value of $\alpha_s(M_Z^2)$ is the same as in the non-singlet case [1]. The comparison between the FFNS and the BMSN scheme [13] for the description of the heavy flavor contributions induces a systematic uncertainty $\Delta\alpha_s(M_Z^2) = 0.0006$. The NNLO analyses of Ref. [4] are statistically compatible with the results of [1–3], while those of [5] yield a higher value.

In Ref. [6] the combined H1 and ZEUS data were accounted for in a NNLO analysis for the first time, which led to a shift of $+0.0012$. However, running quark mass effects [14] and the account of recent F_L data reduce this value again to the NNLO value given in [3]. We mention that other recent NNLO analyses of precision data, as the measurement of $\alpha_s(M_Z^2)$

using thrust in high energy e^+e^- annihilation data [7,8], result in lower values than the 2009 world average [9] based on NLO, NNLO and N^{3}LO results. The sensitivity of the fits to a precise description of the longitudinal structure function F_L has been demonstrated in [15] recently, in the case of the NMC data. Inconsistent descriptions of F_L induce a high value of α_s of ~ 0.1170 to be compared with that obtained in [5]. It is observed that the values of

$\alpha_s(M_Z^2)$	with $\sigma_{\rm NMC}$	with $F_2^{\rm NMC}$	difference
NNLO	0.1135(14)	0.1170(15)	$+0.0035 \simeq 2.3\sigma$
NNLO $+F_L$ $O(\alpha_s^3)$	0.1122(14)	0.1171(14)	$+0.0050 \simeq 3.6\sigma$

α_s found in NLO fits are systematically higher than those in NNLO analyses. α_s measurements based on jet data can be performed presently at NLO only. Here typical values obtained are $\alpha_s(M_Z^2) = 0.1156\ ^{+0.0041}_{-0.0034}$ [16], $\alpha_s(M_Z^2) = 0.1161\ ^{+0.0041}_{-0.0048}$ [17] in recent examples. The precise knowledge of $\alpha_s(M_Z^2)$ is of instrumental importance for the correct prediction of the Higgs boson cross section at Tevatron and the LHC [18].

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